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FOUNDATION PROBLEMS OF KERR NO. 3 HYDRO PLANT

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POWER DIVISION

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FOUNDATION PROBLEMS OF KERR NO. 3 HYDRO PLANT

H. H. Cochrane[1] and R. A. Sutherland[2], M. ASCE

SYNOPSIS

A difficult foundation problem of constructing an extension to an existing power house in a deep cleft in the rock river bed was successfully overcome by a process of grouting rock and gravel fill. To conserve space a truncated draft tube design was used. An unusual arch cofferdam was used to isolate and unwater the working area.

INTRODUCTION

The Kerr Hydro-Electric Development of the Montana Power Company is located on the Flathead River about four miles below Flathead Lake, near the town of Polson, Montana. It consists of an overflow arch dam 200 feet high, a power house on the opposite side of a hairpin bend in the river, and connecting tunnels between the intake and the power house. The dam and first unit of the power plant were constructed in 1938, the unit having a rated capacity of 56,000 KW. At that time provision was made for a second unit, by providing intake facilities and power house substructure and stub ends of the second tunnel. The second unit installation was completed in 1948. As a consequence of the Hungry Horse dam and the resulting increase in the regulated flow of the stream, it was decided in 1951 to add a third unit of similar capacity to each of the first two. The most desirable location for the third unit from an operation point of view, was on the downstream side of and in line with the existing units, but the depth to bed rock below tailwater at this point, in line with the downstream edge of the existing plant was about 90 feet. Since the side of the river bottom shelves down very steeply, any conventional method of cofferdamming was out of the question, and some consideration was given to a location of the third unit in a semi-underground plant tunnelled out of the rock cliff. This would in effect make a separate plant, with consequent increased expense for handling facilities and operating personnel, and it was decided to overcome the inherent difficulty of the preferred location. Figure 1 shows the general layout of the dam, tunnels and power plant.

Consolidation of Foundation

It was first necessary to make a solid foundation on which to build the extension. Investigation by drilling showed that the rock bottom in

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line with the existing edge of the power house varied from 65 feet to as deep as 90 feet below normal tailwater of 2705. On top of the rock was a sloping talus of rock debris, some or most of which had come from dumping of tunnel spoil from the original construction in 1937 and 1938. This talus was built up to a level platform at approximately elevation 2665 and extending out approximately in line with the downstream edge of the existing power house, by dumping gravel and smoothing this fill off to an approximately level surface. Grouting of the previous fill to elevation 2665 was accomplished by 30 drill holes not including 10 holes used only for investigation of the subsurface conditions. It was estimated that the volume of fill below elevation 2665 and bounded by the continuation of the downstream edge of the existing power house was 36,600 cu ft and that the theoretical quantity of grout required for grouting this fill would be about 11,000 cu ft (assuming 30 per cent voids) but because of leakage into the river and spreading out of the grout a quantity of 45,192 cu ft was actually used. The following proportions by volume were in general used for the grout.

	Loose Fill	Medium Tight	Hard Pumping
Cement cu ft	2	2	2
Alfesil cu ft	1	1	1
Sand cu ft	5	3	0
Water (galls)	16	17	19

The maximum pressure was 150 psi.

Figure 2 shows a plan of the cofferdam layout, Figure 3 a developed section along the curve of the cofferdam and Figure 4 a cross section.

This work of grouting the debris was tedious and rendered more difficult by weather and frequent fluctuations of the water in the river. The results of grouting any one hole was constantly checked in adjacent holes.

Arched Cofferdam

In the layout of the plant it was apparent that the length from centerline of the unit to the downstream face of the draft tube should be reduced to the minimum, since the work of consolidation and cofferdamming would become increasingly difficult as the distance out from the bank increased. It was found possible, in cooperation with the turbine manufacturer, to reduce the horizontal length of draft tube, as compared with those previously used, by as much as 17 feet, without seriously imparing the efficiency of the unit. The centerline of unit could also be set back 3 feet, thus saving a total of 20 feet, in extension toward the river. The depth of the draft tube was increased by 4 feet. This reduction in the length of draft tube enabled the working area to be isolated by means of an arched cofferdam spanning between the rocky abutment of the river and the existing power house. A special haunch member was constructed to take the thrust adjacent to the power house without imposing an undue load on the existing structure. The cofferdam was constructed as follows:

Sheet piling was set up vertically to form a cell four feet wide and ten feet long, outlining a segment of the cofferdam. Alignment was

established by steel templet set up and anchored just above the water level. The piling was driven down to the consolidated rock foundation but did not penetrate the rock to any extent. The joint between the bottom ends of the piling and the rock foundation was made tight by piling sand bags on the outside of the joint. The inner and outer walls of the cell were tied together by $\frac{1}{4}$" rods, spaced from four to six feet vertically and going through alternate lengths of piling. Removable nuts on the ends of these rods allowed the piling to be stripped from the concrete after the concrete had been placed. The concrete was poured with a tremie in ten foot lifts. The pours were made from bottom to top on succeeding days.

Having completed one cell, the forms were stripped and set up to form the next segment of the arch and so on until the arch had been completed.

There was no special joint between the separate sections of the dam but it might be pointed out that inasmuch as sheet piling used for the forms resulted in an indented or zigzag contour on the radial face of each section, this irregularity served very nicely as a key between sections.

Figure 5 shows the cofferdam construction and Figure 6 shows the working area unwatered. A comparison of the new and old draft tubes is shown in Figure 7. No model tests were made on the truncated draft tube, but it was the manufacturer's opinion based on available information, that the effect of the reduction in length would be almost entirely compensated by the increase in depth.

Chronology of Construction

Active engineering studies commended about October 1951. Grouting of the fill in the river bed was started in December 1951, and finished in April 1952. Construction of the cofferdam took place between August 1952 and December 1952. The area behind the cofferdam was unwatered in January 1953, and the power house external structure was substantially completed by May 1954.

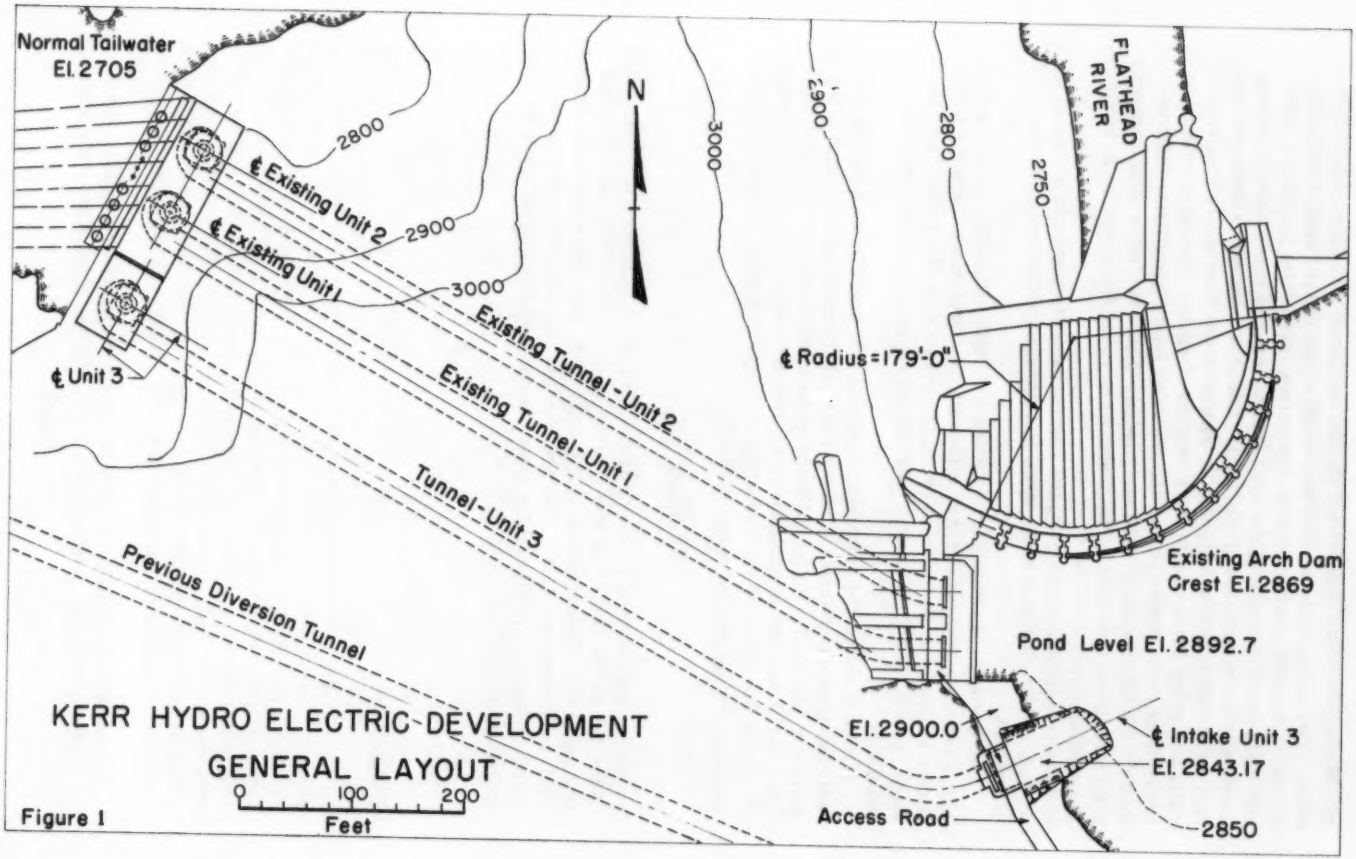
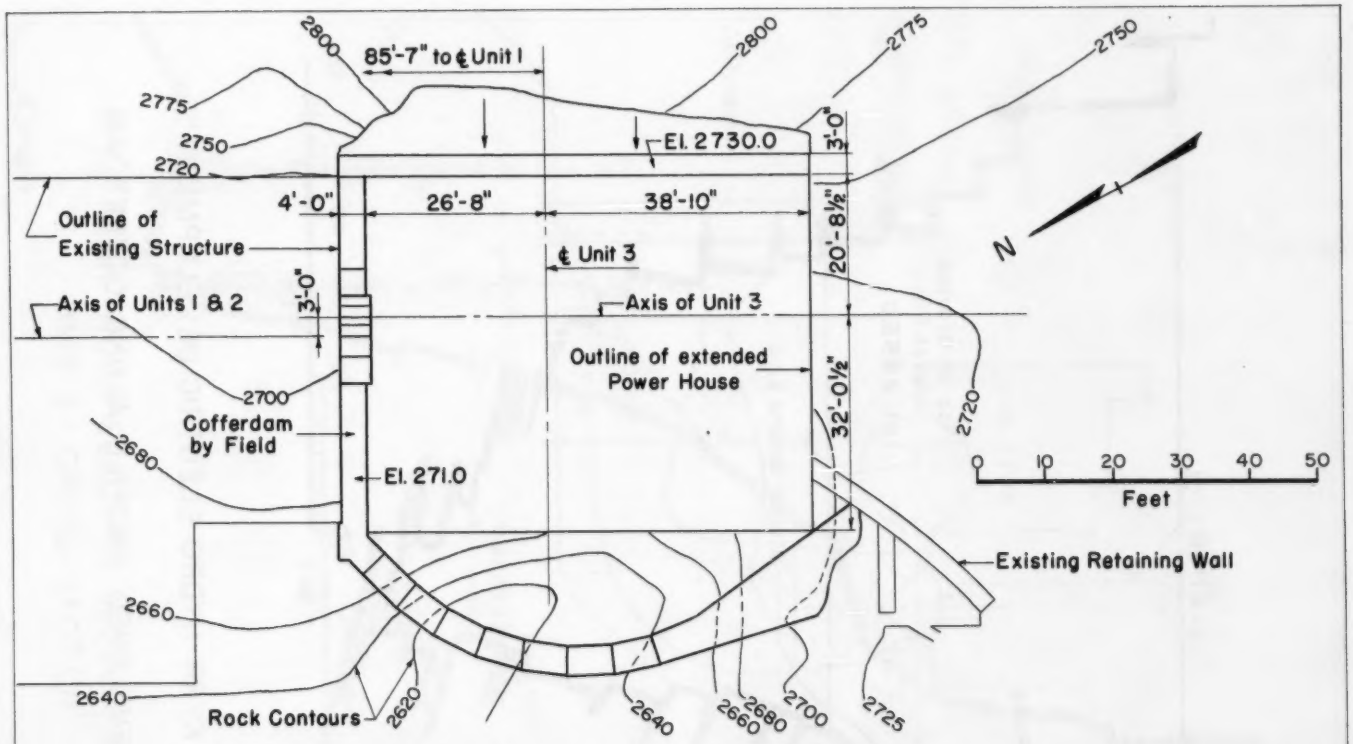

Normal Tailwater
El. 2705
2800
℄ Existing Unit 2
2900
℄ Existing Unit 1
3000
℄ Unit 3
Existing Tunnel - Unit 2
Existing Tunnel - Unit 1
Tunnel - Unit 3
Previous Diversion Tunnel
N
3000
2900
2800
2750
FLATHEAD RIVER
℄ Radius = 179'-0"
Existing Arch Dam
Crest El. 2869
Pond Level El. 2892.7
El. 2900.0
℄ Intake Unit 3
El. 2843.17
Access Road
2850
KERR HYDRO ELECTRIC DEVELOPMENT
GENERAL LAYOUT
0 100 200
Feet

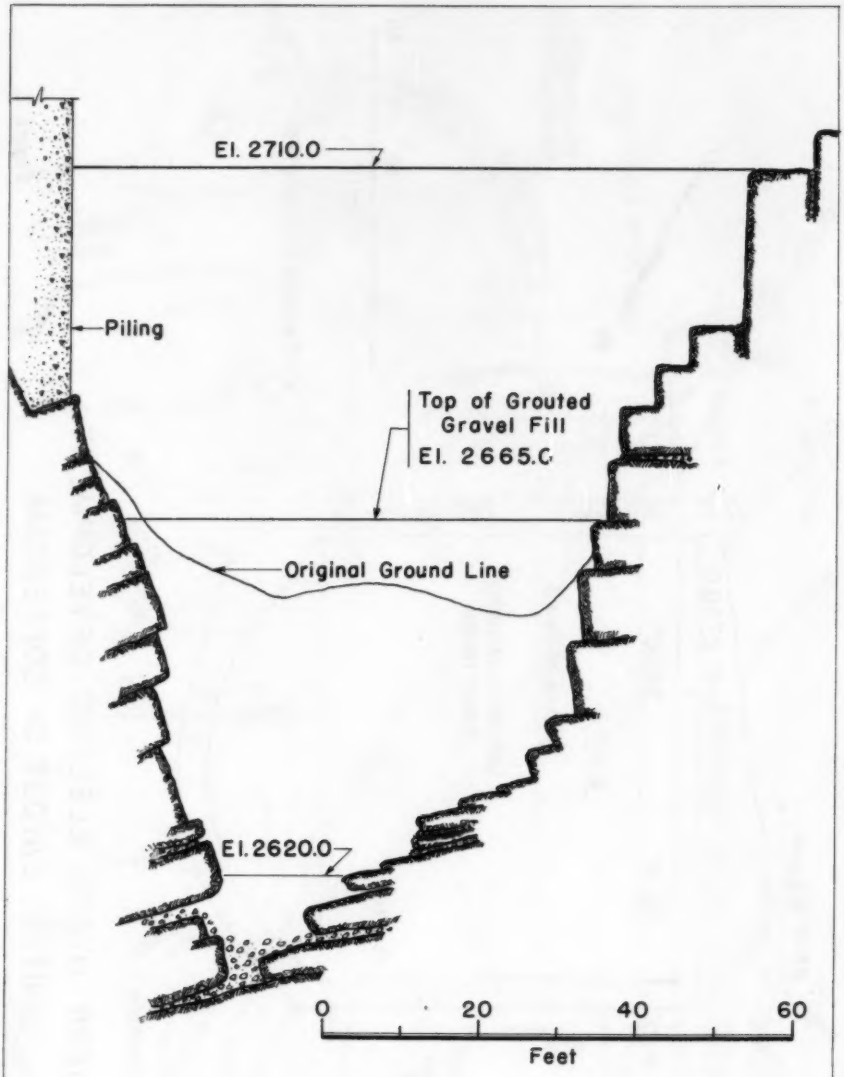
Figure 1



KERR HYDRO ELECTRIC DEVELOPMENT

UNIT 3 - LAYOUT OF COFFERDAM

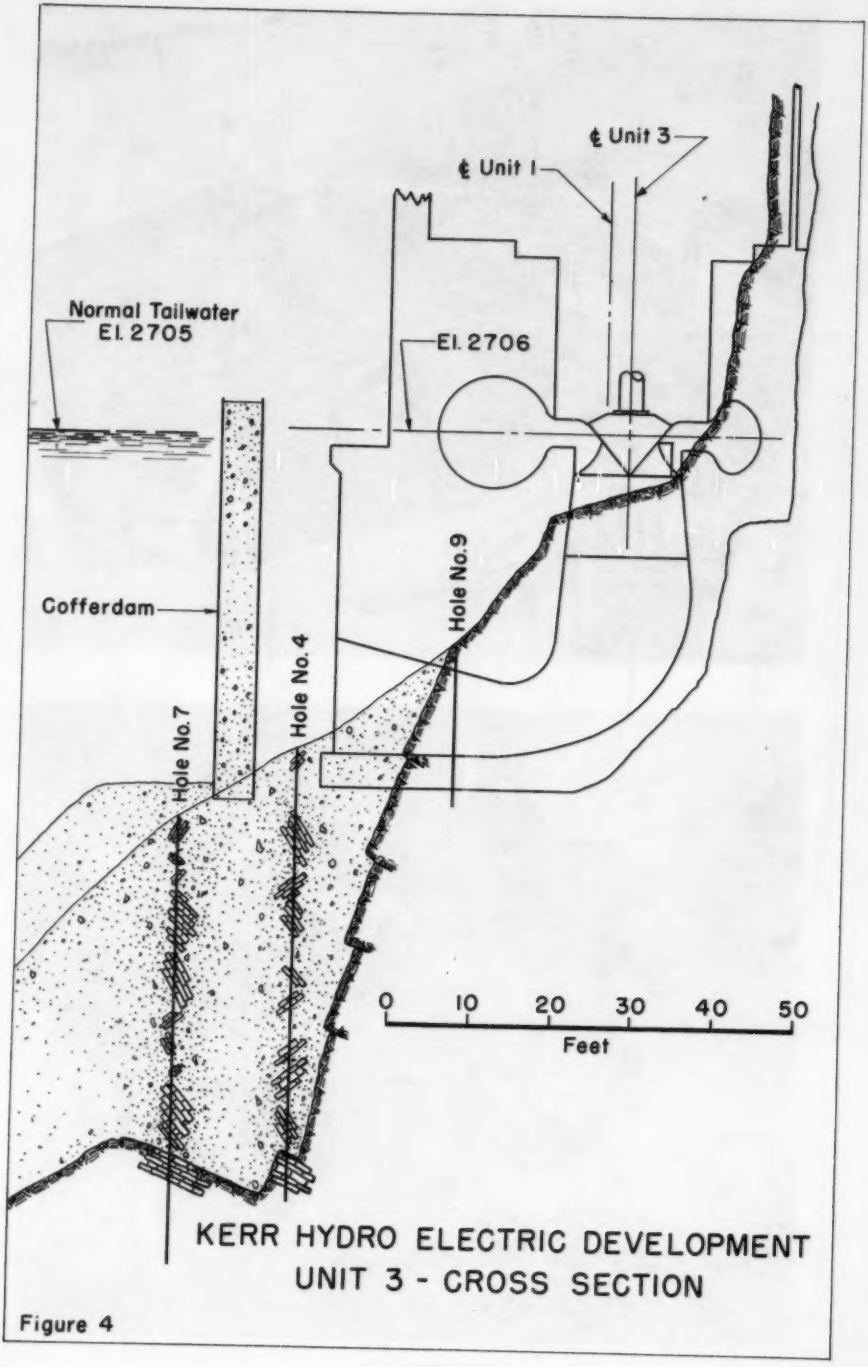
Figure 2



KERR HYDRO ELECTRIC DEVELOPMENT

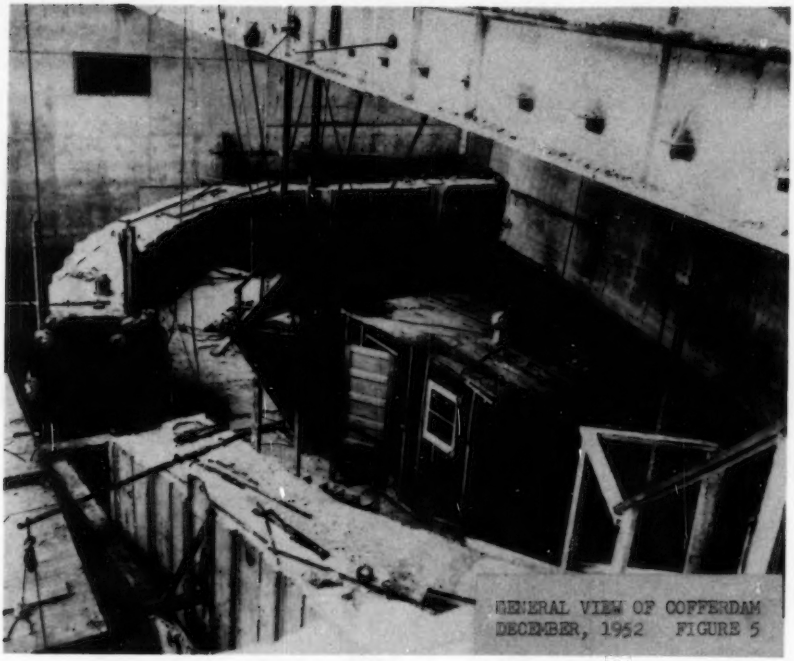
DEVELOPED PROFILE ALONG COFFERDAM

Figure 3



KERR HYDRO ELECTRIC DEVELOPMENT
UNIT 3 - CROSS SECTION

Figure 4



GENERAL VIEW OF COFFERDAM
DECEMBER, 1952 FIGURE 5

VIEW OF POWERHOUSE EXCAVATION
FEBRUARY, 1953 FIGURE 6

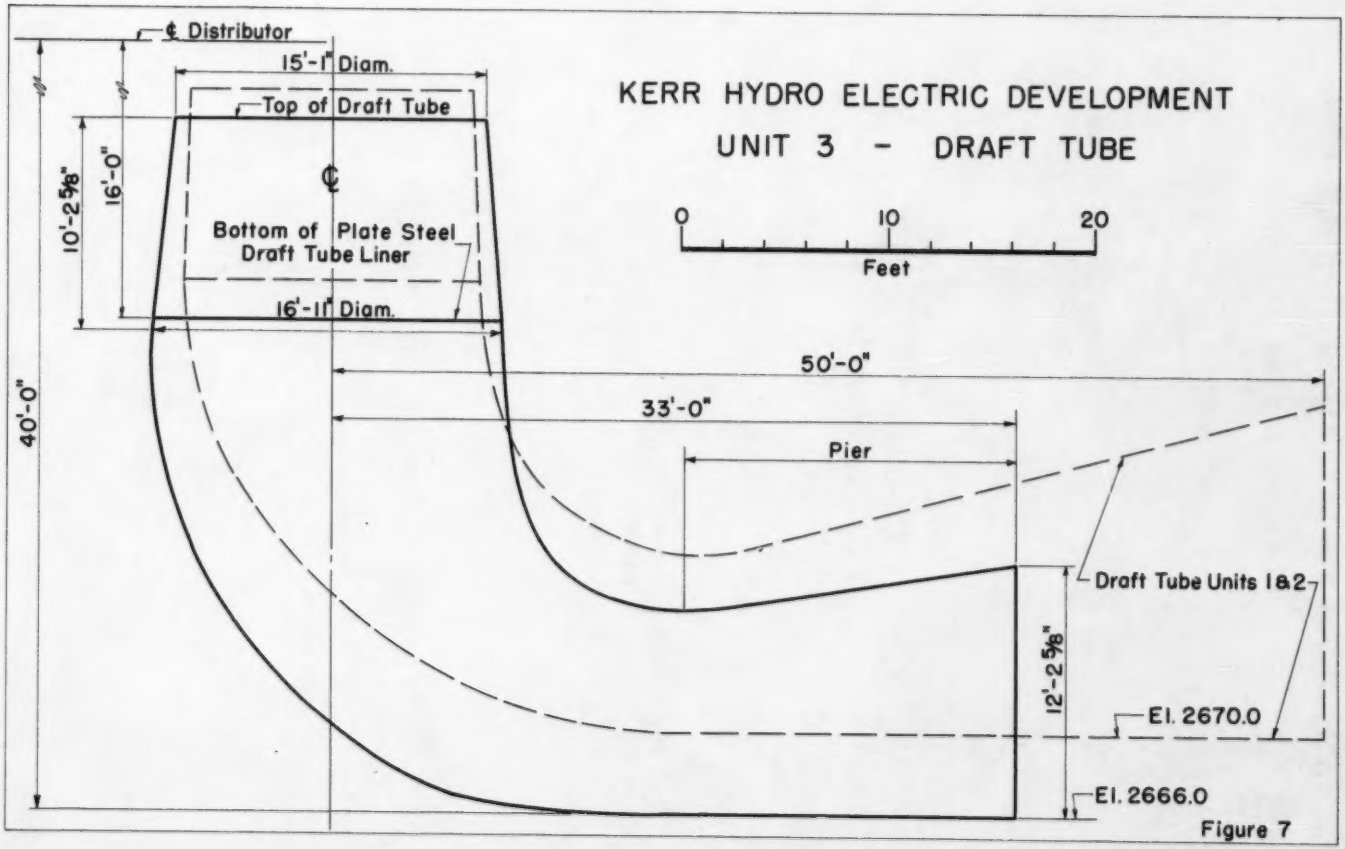

KERR HYDRO ELECTRIC DEVELOPMENT
UNIT 3 - DRAFT TUBE
℄ Distributor
15'-1" Diam.
Top of Draft Tube
10'-2⅝"
16'-0"
℄
Bottom of Plate Steel Draft Tube Liner
16'-11" Diam.
0
10
20
Feet
50'-0"
33'-0"
Pier
40'-0"
Draft Tube Units 1&2
12'-2⅝"
El. 2670.0
El. 2666.0
533-9

Figure 7

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